A Primer for VHF/UHF Omni-directional Vertical Antennas for EMcomm Usage

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Introduction:

We will not discuss HF antennas, as it is more complex because of ground effects; which are usually not severe factors in VHF/UHF. The frequencies on HF that are most widely used in disasters are 80m, 60m, and 40meters because these wavelengths offer most reliable short and medium range coverage when line of sight comms are impossible in hilly terrain, valleys, canyons, and so on into distant county seats, and state capitols. We will also NOT discuss electromagnetic propagation effects due to the Sun and moon, weather effects, the effects of VHF and UHF frequency characteristics, or advanced antenna theory, in order to make this primer practical and accessible to new hams. How to achieve that will be the focus of this study. We do recommend the ARRL Antenna Handbook for those who want to learn more.

The general principle is to move all the power from the radio through a lossless transmission line (usually coax), to the antenna, which in turn will direct the signal out to the desired receiver. General principles include having the antenna free from nearby objects “up in the clear”. Especially troublesome are metal, rock, earth, and masonry objects. Working in a steel concrete building is not advised. Line of sight matters to an extent; (the higher the antenna the better) but bounce and bending can and does occur. A 5 watt ht can go 40 miles easily when there are no obstructions; but it will not work for 3 miles when there is a hill in the way.

Similarly, antenna gain is important. It increases your signals both ways for the receiving station boosting their ability to hear and on the transmitting end as well (called the reciprocal relationship

All you really need to know

Get your antenna up as high as is practical
Keep the radiating area free from nearby objects (including people)
Use a gain antenna (anything but a rubber duck is best). A ¼ wave vertical is better than a rubber duck. A half wave vertical is better than a ¼ wave vertical, A 5/8 wave vertical is the best practically speaking. These are all available as mag-mounts or you can build one yourself. For mobile antenna try the ½ wave dual band Tram 11861 magmount. Diamond sells a 5/8 wave 52” magmount. We don’t recommend anything larger because of tree branches.

For base or portable stations use collinears. These are stacked with two or more tuned radiators on top of each other with phasing and matching networks. A bit complex to build but plans are readily available on the world wide web and in books. For our purposes aspire to the Tram 1480 (2 stacked

5/8th wave radiators.

If your transmission line exceeds 30' use low loss coax such as 9913f, lmr-400, or equivalent.

More than what you really need to know

Consumer Products:

Tram 1480 8' dual band gain vertical
Diamond X-50a 5' dual band vertical
Diamond X-200a 8' dual band vertical
Diamond X-300a 10' dual band vertical
Tram 11861 magmount mobile antenna
Heavy Duty Speaker Tripod (EBAY or Amazon)
Telescoping mast (EBAY)
Coax -- LMR-400 RG-9913, etc. K1cra.com
VHF/UHF SWR Meter - $50 and up
Antenna analyzer $350 -- $1000
GMRS: Most ham ntnnas will work reasonably well on GMRS; but for the most efficiency get a GMRS antenna tuned for the 460-470 MHz Band

Nagoya 701C (HYPERLINK "https://www.amazon.com/Nagoya-NA-701C-Commercial-SMA-Female-BTECH/dp/B01AX3AYOK/ref=sr_1_fkmrnull_3?keywords=nagoya+701c" \t "_blank" https://www.amazon.com/Nagoya-NA-701C-Commercial-SMA-Female-BTECH/dp/B01AX3AYOK/) for the GMRS-V1 (Note that you want the **"C" or "commercial"** also the Comet HT-55 (HYPERLINK "http://www.cometantenna.com/land-mobile/hand-held-antennas/" \t "_blank" http://www.cometantenna.com/land-mobile/hand-held-antennas/) is also designed for GMRS.

For GMRS Base station antennas Comet CA712-EFC (HYPERLINK "http://www.cometantenna.com/land-mobile/base-antennas/uhf-antennas/" \t "_blank" http://www.cometantenna.com/land-mobile/base-antennas/uhf-antennas/) or Diamond X50-C2 (HYPERLINK "https://www.diamondantenna.net/x50c2.html" \t "_blank" https://www.diamondantenna.net/x50c2.html)

Likewise there are commercial mobile GMRS antennas available.
For a short consumer guide for antennas see KaroEcho's summary HYPERLINK "https://drive.google.com/file/d/1u_ozABBRYDJDACFJRTV_rxWF1WjCgW_I/view" https://drive.google.com/file/d/1u_ozABBRYDJDACFJRTV_rxWF1WjCgW_I/view
For more details. See the ARRL Antenna Handbook

Antenna Gain

In electromagnetics, an antenna's power gain or simply gain is a key performance item; which combines the antenna's directivity and electrical efficiency. In a transmitting antenna, the gain describes how well the antenna converts input power into radio waves headed in a specified direction. By direction we mean, the antennas radiation angle to the horizon. In a receiving antenna, the gain describes how well the antenna converts radio waves arriving from a specified direction into electrical power. . .

Antenna gain is usually defined as the ratio of the power produced by the antenna from a far-field source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna,

which is equally sensitive to signals from all directions. Usually this ratio is expressed in decibels, and these units are referred to as ‘decibels-isotropic’ (dBi). An alternative definition compares the received power to the power received by a lossless half-wave dipole antenna, in which case the units are written as dBd. Since a lossless dipole antenna has a gain of 2.15 dBi, the relation between these units is Gain (dBd) = Gain (dBi) -2.15; or equally, to convert dBi figures into dBd figures Gain (dBi) = Gain (dBd) +2.15. For a given frequency, the antenna's effective area is proportional to the power gain. An antenna's effective length is proportional to the square root of the antenna's gain for a particular frequency and radiation resistance.
An isotropic antenna (one that radiates in all planes and directions equally) exists only in theory. It is defined as 2.1 dB down from a halfwave dipole (or minus dBd gain). Therefore, a halfwave dipole is said to provide 2.1 dBi gain over the reference isotropic standard (the “I” stands for isotropic). Now as we all know, a ½ wave dipole radiates broadside (perpendicular to the line of its conductor); while creating a null off its ends. If we stand the dipole up on its end, it will radiate equally in all directions perpendicular to its conductors but not straight up nor straight down. This is how it concentrates its radiation off its sides (east, west, north, and south equally in all directions over that of an isotropic radiator which radiates upward and downward as well assuming the feed point and feedline do not affect the radiation pattern. Similarly we will assume that a properly counterpoised ¼ wave vertical on VHF/UHF exhibits 2.1 dB gain over an isotropic antenna, because it is acting like a vertical dipole (well almost). That is 2.1 dBi gain.

Gain is improved by focusing your signal (decreasing beamwidth while increasing focus). Here we focus our beam along the horizon; while any beam up into the sky and down into the ground is wasted radiation.

Gain is measured relatively or comparatively. Here we have measured a ¼ wave vertical over that of an isotropic radiator. One could measure gain over a rubber duck, over a dipole (a multi-element array, a yagi, a multi-element quad, a rhombic antenna, a parabolic reflector (dish), a log periodic, etc. There are no limits of antenna designs. **Gain over what** is the primary question. Is it gain over a wet noodle, a stubby rubber duck, a rubber duck, an extended rubber duck, an isotropic antenna, a ¼ wave dipole or half wave dipole etc?

Antenna gain is rated in decibels (dB). 3 dB gain is equivalent to doubling your signal. Every doubling gives you an additional 3 dB gain. 10 watts is 3 dB gain over a 5 watt transmitter. Put another way adding, 3dB gain to an antenna system will double your signal strength. Similarly, 6 dB gain doubles the signal strength again (in this case to 20 watts. An additional 3 dB gain will add the total gain to 9 dB and is equivalent to 40 watts given that coax transmission line loss is not increased. Antenna gain is superior to simply increasing transmitter power; because it also gives you receiver gain. A 10 dBd gain antenna is much more sensitive than a ¼ wave vertical or many times that figure over a rubber duck antenna (rubber ducks are generally negative dBi gain). Using a gain antenna gives you all the advantages of high power with an added bonus of exceptionally sharp reception. .

Beware: dBi versus dBd Gain

"dBi" stands for "antenna gain in dB above an isotropic radiator"; "dBd" stand for "antenna gain in dB above a resonant half wave **dipole** antenna". An isotropic radiator is a fictitious/theoretical radiator that radiates evenly in all spatial directions. For comparison: 0 dBd = 2.15 dBi…

In order to avoid confusion, note that a 1/2 wave vertical dipole exhibits 2.14 dB gain over an isotropic radiator; while we will consider a ¼ wave vertical with radials to be an analogue to the ½ wave dipole. .

Antenna performance is primarily established by its gain. This term generally refers to gain over an isotropic radiator (dBi), a theoretical antenna that radiates equally all directions. However **dB gain is a relative term**. It may refer to gain over a wet noodle, a stubby rubber duck, an isotropic antenna, a quarterwave vertical, etc.

This is where antenna gain hype often becomes misleading. An Antenna rated at 2.14 dBi gain is exactly 2.14 dB down from an antenna rated at 2.14 dBd or really zero dBd gain. For example, a reference dipole has 2.15 dB higher gain than an isotropic

So pay attention to the ratings whether it is in dBi or dBd. For example, note that a reference dipole has 2.14 dB higher gain than an isotropic antenna. An isotropic antenna is simply an imaginary antenna that radiates equally in all directions; which is less efficient than a ¼ wave vertical. This makes sense, because an isotropic antenna radiates equally in all directions, whereas a dipole concentrates the radiation broadside from its axis with nulls off the two ends.

Remember 70 cm and 2 m are nominal wave length place holders. 146 MHz and 444 MHz is only approximately 2 m and 70 cm, respectively.

We will use **Thus, for a half wave dipole we will use 468'/freq in MHz, to find the length in feet. For a quarterwave wave vertical formula is 234'/freq in MHz.** This is the practical formula that we will use. For 70 cm 444MHz we divide 234/444 = 6.3". For FRS/GMRS (465 MHz) we get 6", and for 145 MHz we get 19.2". From here we can calculate 1/2 wave , 5/8 wave, and other multiples. In all antenna calculations matching the feedpoint impedance is often critical..

A 5/4-wave dipole antenna has a much lower but not purely resistive feedpoint impedance, which requires a HYPERLINK "https://en.wikipedia.org/wiki/Matching_network" \o "Matching network" matching network to the impedance of the transmission line. Its gain is about 3 dB greater than a half-wave dipole, the highest gain of any dipole of any similar length.

Gain of dipole antennas
Length, L, in wavelengths HYPERLINK "https://en.wikipedia.org/wiki/Directivity" \o "Directivity" Directive gain HYPERLINK "https://en.wikipedia.org/wiki/Decibel" \l "Antenna_measurements" \o "Decibel" (dBi)

Notes		
≪0.5	1.76	Poor efficiency
0.5	2.15	Most common
1.0	4.0	Not used
1.25	5.2	Best gain
1.5	3.5	Third harmonic

Notice that the 1.25 long dipole is called a double extended zepp (a great antenna for HF if you have the space). Notice also that 5/8 (0.625) dipole is not mentioned. It is also a good performer but needs base matching, thus producing gain over a halfwave dipole. A 5/8 wave vertical exhibits approximately 5.2 dBi or 3.1 dBd gain.

Notice that 5/8 plus 5/8 wave = 10/8 = 5/4 Dipole, which equals a stacked collinear 5/8 wave vertical; which equals 5.2 dBi gain; if we stack them as 2 5/8 wave vertical elements we get 6.2 dBd gain and 10.4 dBi gain (minus any matching section losses). How tall is this antenna? It is 5 quarter wave lengths tall = 8' on 2m or 31.5" on 70cm

Summary:
19.2” is the length of a 2.14 dBi or unity gain (0 dBd gain) quarterwave vertical on 2m

38” is the length of a 4 dBi (or 1.85 dBd) gain 1/2 wave vertical on 2m

48” is the length of a 5.2 dBi (or 3.1 dBd) gain 5/8 wave vertical on 2m

8’ is the length of a 8.1 dBi (or 6dBd) gain 2m stacked 5/8 vertical collinear on 2m

Resonant Antenna lengths (wavelengths): Using the ½ wave Dipole as a starting point

As we know a half wave dipole consists of two ¼ wave sections fed at the midpoint, rated at 2.14 dBi (gain over isotropic). Here we will consider a ¼ wave vertical antenna to be ½ length of a 1/2 wave element, where the radials or counterpoise serve as the missing element. Thus, we will make an approximate assumption that a quarter wave vertical operates similarly to a vertical half-wave dipole in free space, given that the vertical has an effective ground plane, counterpoise, radial system, or tiger tail leg. This approximation works well for VHF/UHF antennas. Since the isotropic antenna is an intellectual fiction, evidential measurements or confirmations are not possible; but we can perform field strength comparisons with vertical dipoles. The isotropic model is useful for theoretical design and computer modeling and is widely used, especially when modelling complex situations on HF above various terrains..

As we all know, the higher in frequency we go, the shorter is the wave length. Using the formula **λ = c / f** = wave speed c (m/s) / frequency f (Hz) ; where λ (lamda) is the wavelength, C is the speed of light in a vacuum (approximately 300 km/sec.), and f is the frequency in MHz (Mega-Hertz), we find that a 40m vertical is approximately 33 feet long; but a **2 m 1/4 wave vertical** is approximately only 19.2” long. By calculating the length of a ½ wave dipole using the formula 2m X .5 X .95 (velocity factor correction for the speed of electrons in a copper wire conductor) = 38” and then halving it, we get a **¼ wave vertical** on 2m at approximately 19”. Note, that at 146.000 MHz it is actually, 19.2” because 2m is a nominal length.

From the same formula **“f” [frequency] =c/λ** . C being the velocity of light and lamda the wavelength. To determine the actual f (frequency) = divide the velocity of light (in meters/second) by the wavelength in meters (m). The speed of light in a vacuum is approximately 300,000 km/s or 186,000 miles/s. However, the velocity of radiowaves in various varies according the material (in this case copper wire). We also make corrections for the velocity factor in a conductor (usually copper, steel, or aluminum) and coax. The effect of antenna length on reactance is much greater for thinner conductors. For the same reason, antennas with thicker conductors have a wider operating bandwidth over which they attain a more efficient standing wave ratio.

For a typical k (velocity factor) of about 0.95, the ½ wave dipole formula is often written for a length in meters of 143m/f, or a length in feet of 468’/f where f is the frequency in megahertz. **Thus, a ¼ wave vertical formula is 234’/freq in MHz.** This is the practical formula that we will use.

2m and 70 cm are nominal approximations for our ham band designations. Beware that 146.000 MHz is not exactly 2 meters; rather a 2m ½ wave dipole is resonate at 143 MHz (outside the ham band): thus, a resonant ¼ wave vertical antenna at 146 MHz will be shorter than 2m/4 = .25 meters or 20”. It will be closer to 19”.

19.2” is a good number for a 2m ham band antenna centered at 146.00 MHz and 6.35” is a good length for centering in the 70 cm (nominal) ham band. Notice that 441 MHz (70cm band) is the third harmonic of 147 MHz (2m band). 19.2” and 6.3” are good lengths for ¼ wave ham verticals centered in the 2m and 70cm ham bands respectively. Notice they are half the length of a half wave dipole.

As a general rule for a ¼ wave vertical use the formula **length in feet = 234 divided by frequency in mHz (L’= 234/f (mHz)**. For a half wave dipole use 468/frequency in MHz. Therefore, a quarter wave vertical centered at 146.000 MHz would equal 234/146 = 1.6’ or 19.2 inches.

Likewise a ¼ wave vertical centered at 446 MHz would = 234/446 = .524’ or 6.3 inches

Similarly, for a FRS/GMRS ¼ wave antenna 234/ 464.5 MHz = .5’ or 6 inches

Some numbers for ¼ wave verticals (double for total length of ½ wave dipoles):

146.000 MHz (2m)	19.2”	Hint: Start @1” longer and trim .25” at a time
MURS 153 MHz	18.35”	Start @1” longer and trim .25” at a time
444 MHz (70cm)	6.35”	Hint: Start a bit longer and trim .1” down at a time
FRS/GMRS 464 MHz	6.0”	Hint: Start a bit longer and trim .1” down at a time
52 MHz (6m)	54”	
28.5 MHz (10m)	8.2’	
7.20 MHz (40m)	32.5’	
5.380 MHz (60m)	43.5’	
3.900 MHz (75m)	60’	

Calculators:
HYPERLINK "http://www.csgnetwork.com/antennagenericfreqlencalc.html" http://www.csgnetwork.com/antennagenericfreqlencalc.html
HYPERLINK "https://www.qsl.net/kd4sai/antencal.html" https://www.qsl.net/kd4sai/antencal.html
HYPERLINK "http://www.westmountainradio.com/antenna_calculator.php" http://www.westmountainradio.com/antenna_calculator.php
The above are similar; but this calculator gives additional info:
HYPERLINK "http://www.66pacific.com/calculators/quarter-wave-vertical-antenna-calculator.aspx" http://www.66pacific.com/calculators/quarter-wave-vertical-antenna-calculator.aspx

You can think of a 1/2 wavelength long dipole as having two sections, each one quarter wave length long as we all know that ¼ plus ¼ equals ½ wave length total. The feed point of a ½ wavelength horizontal dipole fed at its center is approximately 72 ohms, but a typical ¼ vertical is less than 40 ohms. Modern transceiver input impedance is nominally 52 ohms, hence we normally use 52 ohm coax.

Notice that the difference in length between 446 MHz and 464.5 MHz (almost 20 MHz) is only .3 inches as we approach microwave lengths. Compare that with the amateur radio 80m band difference between 3.5 MHz and 4 MHz which is only a .5 MHz difference in terms of frequency; but 66’ versus 58.5 feet or almost 8’ difference in wavelength of antenna and 5 meters in overall wavelength. **Why is that given the formula length = 234/freq in MHz? An 80m** dipole or vertical typically has a reasonable bandwidth of only 100 -150 Khz until the SWR goes too high for solid state rigs; hence antenna tuners are in wide use on HF. **What is bandwidth and what factors determine increases and decreases in bandwidth?**

Transmission line (coax) loss, SWR, coax connector (insertion loss), and antenna analyzers,

Connectors:
Every time we put on an antenna connector, adapter, or antenna switch there is loss.
Most modern HTs and radios have SMA, BNC, PL-259 (UHF), or N connectors for coax. The least lossy are N connectors recommended for UHF as they are the least lossy and well built. BNC connectors offer quick connect/disconnect. Base stations and base antennas in the Amateur Radio Service usually take PL-259 (UHF) connectors. At UHF and higher an N connector will save almost .5 dB loss over a UHF (PL-259) connector.

Transmission Line Loss
Hams usually use coax on VHF/UHF. Better than coax is hardline (heliax); which is very low loss, but very stiff and expensive. Hardline is used most often at repeater sites.
Coax cable differs greatly in loss factors at UHF and a bit less lossy at VHF. In short, the higher the frequency given the same coax, the greater the loss. Similarly the longer the coax run, the greater the loss. Coax is usually rated as loss (in dB) per foot at different frequencies.

Cutting to the chase, keeping your coax run short is wise. If running over 30’ on UHF (70 cm) use low loss coax such as RG-9913, 9914, LMR-400, LMR-600, etc. Less expensive is Belden RG-213 or Davis RG-214. If the run is 30’ or less Belden Rg-8x (mini-foam), lmr-240, tws-240, Belden RF-240, etc. will suffice. I do not recommend RG-58 because of loss, granted that it is the least expensive and has the smallest profile. 9913, LMR-400, LWS-400, Davis DRF-400, Davis Bury Flex, (and any other 400 series equivalent) can be very stiff and present limitations in their bend ratios. They are available in 9913F (flexible), ultraflex (UF), very flexible and direct burial (underground feed) varieties. If a cable is not listed or approved for direct burial, do not lay it on or underneath the ground.

Velocity Factors for various transmission lines:
 HYPERLINK "https://www.vk4adc.com/web/reference-information/49-general-ref-info/110-coaxial-cable-comparisons" https://www.vk4adc.com/web/reference-information/49-general-ref-info/110-coaxial-cable-comparisons

SWR:
Quarterwave verticals are easy to tune. Just cut them a little over the calculated frequency and measure the resonate frequency with an antenna analyzer to calculate how much to trim. At UHF trim no more than 1/8” off at a time.

Another way to tune a vertical quarterwave dipole is to use a swr meter. The lowest reading should be in the middle of the desired band. If it is lowest at low end of the band start trimming until the two edges of the band are about equal SWR and the middle is the lowest.

Although time consuming, always try to tune any antenna when in place, because nearby objects and ground will affect the resonant frequency. In short, put the antenna in place. Check it (SWR or Antenna analyzer while in place). Take it down to tune it. Put it back up in place. Check it again. Take it down again if needed, and so forth. The anomalies are due to capacitive or inductive coupling. For example if your handheld radio doesn’t have a good counterpoise such as a tiger tail, there will be capacitive coupling between your antenna and your hands that will alter the efficiency of your antenna. Just so, your body and nearby objects will affect your signal through capacitive or inductive coupling effects.

Always test your antenna's standing wave ratio (SWR). SWR more than 2 to 1 on VHF/UHF usually signals a problem (problems such as detuning of the antenna, transmission line kinks/water/ damage, connector dysfunction (bad connection), etc. Modern solid state transceivers will start to go into protection at high SWR by either reducing power output or sometimes eliminating all power output. Those that do not go into protection will fry their finals (the final amplifier will need replacement). High SWR also creates transmission line loss. In all cases your signal will be degraded, sometimes severely, with high SWR. **SO, CHECK YOUR SWR FREQUENTLY OR CONSTANTLY!**

See this simple SWR/Coax loss chart HYPERLINK "https://www.universal-radio.com/catalog/cable/coaxperf.html" \l "atten" https://www.universal-radio.com/catalog/cable/coaxperf.html#atten
A larger sampling here HYPERLINK "http://rfelektronik.se/manuals/Datasheets/Coaxial_Cable_Attenuation_Chart.pdf" http://rfelektronik.se/manuals/Datasheets/Coaxial_Cable_Attenuation_Chart.pdf
Wireman HYPERLINK "https://www.qsl.net/co8tw/Coax_Calculator.htm" https://www.qsl.net/co8tw/Coax_Calculator.htm
See KV5R for a coax loss calculator: HYPERLINK "http://kv5r.com/ham-radio/coax-loss-calculator/" http://kv5r.com/ham-radio/coax-loss-calculator/

Radials, counterpoises, ground-planes, and tiger tails in mobile and portable operations

As above, and in general a ¼ wavelength tall vertical with a good radial/groundplane system (radials serve as the counterpoise or grounded end for the coax shield connection thus serving as the missing half of the vertical dipole. Here-to-fore we have used the ½ wave dipole and the quarterwave vertical as the model to understand VHF/UHF antennas. These antennas have a nominal impedance of 52 ohms. To be clear, the shield itself, does NOT substitute for the missing end of the dipole; rather the shield's connection to the radials or any other counterpoise substitutes for the missing end of the vertical dipole. If the counterpoise is done properly, the antenna impedance remains nominally at 52 ohms; or slightly less (due to the angle effect the vertical element makes with the radials). For the best impedance match, increase the take-off angle of the radials downward to approximately 30-45 degrees. For VHF/UHF 3 or more radials are usually sufficient for mast mounted base antennas. For mobile use, the car's metal roof is best, although trunk lids and other metal appendages may be somewhat less effective. For handhelds, a 19.2" counterpoise (tiger tail) may be helpful especially when the handheld is mostly composed of plastic. In general, a counterpoise, ground plane, radials, or tiger tails are necessary to provide balance to **¼ wave verticals.** A ¼ wave vertical with radials perpendicular to the vertical element has a radiation resistance of 37 ohms; But that can be raised closer to 52 ohms by slanting the radials downward 45 degrees or more.

Radials and steel (iron core) magnetic bases
For a vertical to work well it needs a counterpoise. Height above ground and counterpoise efficiency can be an involved topic in itself, being crucial on HF; but less problematic on VHF and UHF. For VHF/UHF usually 3 or 4 quarter-wave cut radials are sufficient for remotely mounted antennas on tripods or telescoping masts. When at a disaster table you can use a magmount antenna and a steel cookie sheet, pie pan, pizza pan, or sheet metal 2' square or rectangle for an adequate ground-plane. When using radials, they should bend downward at a 45 degree angle or more for best impedance match. There are many other innovative portable antennas in antenna books, such as j-poles, slim jims, coaxial quads, etc; which do not require radials.

For **mobile operation,** the metal roof of an auto for a dual band gain magmount or a through roof antenna is best. Again the taller the better (more gain); however one must be careful of overhanging tree branches when exceeding 4' We recommend the moderately priced ½ wave dual band Tram 11861 all in one (magnet base, coax, connector, and antenna in one) magmount; which is approximately 38" tall (1/2 wave length vertical). Home depot has it complete at $35.all in one (magnet base, coax, connector, and antenna in one) magmount.

A 5/8 wave vertical would be approximately 48" tall (better); but we do not recommend anything taller than 50" when mobile in motion. If using a separate magmount base and antenna, choosing a NMO type may be, arguably, the least lossy (best choice). You can use the mobile antenna for a portable antenna with a suitable counterpoise (see above paragraph).

Tiger Tails

The term, tiger tail, refers to the missing half of the vertical dipole; which completes the vertical with a additional quarterwave section (countepoise). It substtutes for radials, minimizes capacitive hand loading effects, improves the SWR, and increases ERP. Some radios may have a coiled counterpoise within the chassis; but most do not. Although on VHF and UHF one's hand or the chassis itself can act somewhat as a counterpoise, the tiger tail improves both transmission and reception. A stranded flexible #18 wire is cut at a quarterwavelength (19.2 " or a bit longer for 2m) and is attached to the HT through a grounded screw such as the belt clip screw or a ring terminal at the antenna connector. Each radio is different so one must innovate. Yes, it does seem to make the HT a bit more cumbersome to carry; but it improves your communications capability. Use tiger tails with HTs that use directly connected rubber ducks, whips, or ¼ wave verticals.

Portable Antennas

Of course, HTs are portable; but so are many mobile rigs which can be combined in a go-kit with external portable antennas and masts. .
During a disaster, you may be called to operate from your home base station and act as a relay station if you have a good gain antenna, have emergency power, and a good location. For home (base station) operation, the general rule is to get the antenna in the clear of surrounding objects if possible, have a gain antenna, and low loss transmission line. The more gain, the better, albeit at the sacrifice of a taller antenna and higher monetary expenditure. The gain of a 5 foot Diamond X-50a, for example, is approximately 2 dB down from a Diamond X-200a (8') or x-300a (10'). A less expensive model than the x-50a is the Tram 1480 (also 8'). $50 at Home Depot or Ebay.

For portable operation, pick a gain antenna that you can quickly assemble and mount on a portable speaker tripod or telescoping mast. Again, the Tram 1480 is our favorite pick; but for a smaller footprint the Diamond X-50a would be almost as good; but at twice the price. Speaker tripod stands range from $15-$45 on amazon or Ebay.
At all costs avoid rubber flexible antennas. They are anathema for simplex operation in rough terrain.

Mobile antennas (whips).
A whip antenna gets its name from the fact then when in motion the antenna whips back and forth in the wind usually, as designed; because solid rigid elements are more easily subject to breakage. When you hear picket fencing or a wobbly signal, it is usually due to a mobile in motion. Mobile whips range from flexible rubber duck HT mounted antennas to 10' tall fender mounted HF whips.

For **mobile operation,** the metal roof of an auto for a dual band gain magmount or a through roof

antenna is best. Again the taller the better (more gain); however one must be careful of overhanging tree branches when exceeding 4’ We recommend the moderately priced ½ wave dual band Tram 11861 all in one (magnet base, coax, connector, and antenna in one) magmount which is approximately 38” tall. Home depot has it complete at $35.

A 5/8 wave vertical would be approximately 48” tall (better); but we do not recommend anything taller than 50” when mobile in motion. If using a separate magmount base and antenna, choosing a NMO type may be, arguably, the least lossy (best choice). You can use the mobile antenna for a portable antenna with a suitable counterpoise (see the paragraph on radials and counterpoises above).

Building a low cost efficient quarter wave Vertical for 2m, MURS, 70cm, and FRS/GMRS

As per the above formula a quarter wave vertical for:
2M (146 MHz) 19.2”
MURS (Centered at 153 MHz) 18.35”
70 cm (Centered at 444 MHz) 6.3”
FRS/GMRS (Centered at 464 MHz) 6.0”

Cut a solid #14 or #12 copper American Wire Gauge THHN/THWN or equivalent to slightly longer than the desired length.
Strip off 5/8” inch insulation.
Solder the copper conductor to a PL-259 connector
Add strain relief to the pl-259 (RTV, coax sleeve, insulation sleeve, shrink wrap tubing, or similar).
Place the quarterwave vertical in a so-239 magmount mounted on a metal plate (baking pan, steel pizza pan, sheet metal, or similar).
Connect a SWR meter or antenna analyzer between the radio and the antenna. If a SO-239 magmount base is not available place the antenna directly on the antenna output connection of a SWR meter while placing the SWR meter or antenna analyzer distant from nearby objects.
Using low power, key down for short periods adjusting the radio frequency (in VFO or frequency mode) to ascertain the resonant frequency which will be low on purpose. Then start trimming off ¼” (on VHF) or 1/8” (on UHF) of the vertical at a time and recheck the resonant frequency as it moves upward toward the center of the band.
You should find 1.1 to 1 SWR at the resonant frequency and less than 1.5 to 1 at the band’s upper and lower ends.

A) Add a tiger tail to the vertical if using it directly on a handheld for added efficiency.
.
B) The vertical can also be used on a mast with radials in various ways. Use a double ended SO-239 Chassis connector with a copper or metal plate between the two ends. Connect additional radials to the sheet metal or copper plate with bolts; or extend the plate downward at a 45 degree angle. Attach coax to the bottom SO-239.

C) You can do something similar using a standard SO-239 chassis connector with 4 bolt holes, while attaching the radials to the 4 holes on the SO-239 chassis connector.

The neat thing about B is that you can change the vertical from 2m, to MURS, to 70cm, or to FRS/GMRS quickly. The neat thing about C is that the connection is more permanent.

APPENDIX: References

More on Antenna Gain from HYPERLINK "http://www.marcspages.co.uk/rtc/0147.htm" http://www.marcspages.co.uk/rtc/0147.htm

Before we go into any explanations there are some terms that need definition so-as to assist in the explanation of antenna gain.

Radiation Angle: It has been generally accepted that beamwidth is the angle between the two points (on the same plane) at which the radiation falls to "half power" i.e. 3dB below the point of maximum radiation. Using anything other than 3dB does not do an antenna's reputation any good as this could give the impression the antenna has a wider/narrower beamwidth and if a serious engineer looks at this he would, rightly so, discredit the design.

Coverage: The physical geological area where signal is still at a level which can be received, usually described as a radius distance from the antenna site.

Radiation pattern 0dB
To start with let us take a standard ½-wavelength dipole and "suspend" it in free space (i.e. ignore all possible surroundings e.g. the mounting pole etc. that could affect the antenna). The radiation pattern of this antenna is typically referred to as the "doughnut", as sown in the figure below.
 INCLUDEPICTURE "http://dbantennas.weebly.com/uploads/1/0/5/1/10512144/4053981.gif?320" * MERGEFORMATINET

As the materials cannot create power the only other alternative is to focus the wasted energy, for example that which is going skywards, towards a more useful direction being on the horizontal plane. Here the shape of the radiation was changed such that the outer most energy was focused to compliment the middle half, the result being a doubling of the radiated energy along the required plane or effectively a 3dB gain.

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Radiation pattern 3dB (doubles the signal)

This focusing can be even further intensified such that gains of 6dB (4 times) to 9dB (8 times) can be achieved. As illustrated by the resultant two patterns shown below.
 INCLUDEPICTURE "http://dbantennas.weebly.com/uploads/1/0/5/1/10512144/3961073.gif" * MERGEFORMATINET INCLUDEPICTURE "http://dbantennas.weebly.com/uploads/1/0/5/1/10512144/9730826.gif" * MERGEFORMATINET
Radiation pattern 6dB Radiation pattern 9dB

As can be seen the method by which an antenna is made to have "gain" is merely to focus the radiation (i.e. taking the doughnut and flattening it into a pancake) thus intensifying the radiation along the horizontal. Antennas with omni-directional radiation and gains of beyond 9dB are impractical owing to the fact that the focusing is directly related to the length (in wavelengths) of the antenna“.

Mined from HYPERLINK "http://www.marcspages.co.uk/rtc/0147.htm" http://www.marcspages.co.uk/rtc/0147.htm

Making high gain series fed collinears with stacked elements to maximize gain

“Series-fed collinears are very common. They are typically either 1/2 wave coaxial elements of alternating phase, or series-fed 5/8 wave elements. These type of antennas are fairly easy to build. At UHF, the dimensions become critical, however. Knowing the precise velocity factor of the coax you use to make these antennas is very important. Buy high quality coax from a name-brand manufacturer (like Belden, Times Microwave) and use their velocity numbers. I've made a few of these types of antennas for UHF and I've had good luck with 1/4" Andrew SuperFlex. RG393 would also be a good choice, because it has Teflon dielectric, so it won't melt or bubble when you solder to the braid.

Constructions is pretty straightforward, as you've probably seen in the article. A common addition is to add an extra 1/4 wave coaxial section of the opposite phase to the last radiating element, short it at the far end, and add a 1/4 wave piece of wire. This puts the entire antenna at the same DC potential.

The Diamond dual-banders like the X200 and X500 series use series-fed 5/8 sections for UHF, which, when combined with additional phasing coils along the length, are configured to also operate as loaded 5/8 sections on 2m as well. The antenna is usually shunt fed at the base with a series capacitor from coax center to tap point on the coil. I think I remember seeing one of the Diamonds that also had capacitors somewhere along the length of the antenna - don't remember the exact configuration, though.”

The “Go TO” guy is Tom, W8JI, though much more technical than we need here. HYPERLINK "https://www.w8ji.com/stacking_broadside_collinear.htm" https://www.w8ji.com/stacking_broadside_collinear.htm